150 by bolts 181. The fixed member 180 projects from the base portion 110a of the vacuum casing 110 and extends in the vacuum chamber 111 of the vacuum casing 110 to be operatively connected with the handling mechanism, not shown. The fixed member 180 forms part of the sleeve shaft 130 extending in the vacuum chamber 111 of the vacuum casing 110.

The shaft sealing apparatus 100 further comprises a base member 190 in the form of a cylindrical shape and provided on the first axial end 140a of the center shaft 140. The base member 190 is held in axial alignment with the center shaft 140 and fixedly connected with the first axial end 140a of the center shaft 140 by bolts 191. The base member 190 projects from the fixed member 180 and extends in the vacuum chamber 111 of the vacuum casing 110 to be operatively connected with the handling mechanism, not shown. The base member 190 forms part of the center shaft 140 extending in the vacuum chamber 111 of the vacuum casing 110.

The handling mechanism is disposed in the vacuum chamber 111 of the vacuum casing 110 and includes a handling member pivotally supported by the fixed member 180 and the base member 190 to be operative to handle wafers and other substrates in the vacuum chamber 111 of the vacuum casing 110.

While the sealing ring 153 has been described in the above as including an annular spring member 155 made of a metal wire in the form of a helical shape as shown in FIG. 2, the annular spring member 155 may be replaced by an annular spring member made of a metal plate in the form of an annular ring shape as shown in FIG. 3 according to the present invention.

As will be seen from FIG. 3, the sealing ring 153 of the first sealing unit 150 includes an annular resilient member 156 formed with an annular groove 156a, and an annular spring member 157 received in the annular groove 156a of the annular resilient member 156 and retained by the annular resilient member 156. The annular resilient member 156 of the sealing ring 153 has a peripheral portion 156b securely retained by the annular ledge 151e of the retaining member 151, and a sealing lip 156c integrally formed with the peripheral portion 156b of the annular resilient member 156 and radially inwardly extending from the peripheral portion 156b of the annular resilient member 156 to be held in contact with the outer cylindrical surface 140b of the center shaft 140. The sealing lip 156c of the annular resilient member 156 is made of a synthetic resin constituted by an ultra high molecular weight compound.

The annular resilient member 156 of the sealing ring 153 may have a flange portion 156d integrally formed with the peripheral portion 156b of the annular resilient member 156 and radially outwardly extending from the peripheral portion

156b of the annular resilient member 156. The flange portion 156d of the annular resilient member 156 is held in contact with the retaining member 151 of the first sealing unit 150 to hermetically seal the gap between the center shaft 140 and the retaining member 151 of the first sealing unit 150.

The annular spring member 157 of the sealing ring 153 is operative to impart a force to the sealing lip 156c of the annular resilient member 156 to ensure that the sealing lip 156c of the annular resilient member 156 is held in tight contact with the outer cylindrical surface 140b of the center shaft 140. The annular spring member 157 of the sealing ring 153 is made of a metal plate in the form of an annular ring shape and is of a channel-shaped cross-section taken on the plane perpendicular to the center axis passing therethrough. The annular spring member 157 thus constructed is generally called "cantilever spring".

Though the sealing ring 163 has been described in the above as including an annular spring member 165 made of a metal wire in the form of a helical shape as shown in FIG. 2, the annular spring member 165 may be also replaced by an annular spring member made of a metal plate in the form of an annular ring shape as shown in FIG. 3 according to the present invention.

While the shaft sealing apparatus 100 has been described in the above as comprising a sleeve shaft 130 rotatably supported by the shaft housing 120 as shown in FIG. 1, the shaft sealing apparatus 100 may further comprise an intermediate shaft housing intervening between the shaft housing 120 and the sleeve shaft 130 according to the present invention. The intermediate shaft housing is axially movably supported by the shaft housing 120 and rotatably supports the sleeve shaft 130 to ensure that the sleeve shaft 130 is rotatable and axially movable with respect to the shaft housing 120. This fact leads to the fact that the second sealing unit 160 intervenes between the vacuum casing 110 and the sleeve shaft 130 to hermetically seal the gap between the vacuum casing 110 and the sleeve shaft 130 under a rotation and a linear motion of the sleeve shaft 130.

The following description will be directed to a method of assembling the shaft sealing apparatus 100 with reference to the drawings shown in FIGS. 4 and 5. The method of assembling the shaft sealing apparatus 100 is performed through the steps including a preparing step and first to third installing steps as follows.

In the preparing step, the vacuum casing 110, the shaft housing 120, the sleeve shaft 130, the center shaft 140, the first bearing 159, and the second bearing 169 are prepared as a partially assembled unit as shown in FIG. 4. The constructions of the vacuum casing 110, the shaft housing 120, the sleeve shaft 130, the center shaft 140, the first bearing 159, and the second bearing 169 have been described in the

above as will be seen in FIG. 1.

In the first installing step, the second sealing unit 160 constituted by the retaining member 161 and the sealing rings 163 securely retained by the retaining member 161 is installed in the opening 110b of the vacuum casing 110 as shown in FIG. 5. The construction of the second sealing unit 160 has been described in the above as will be seen in FIG. 1.

In the second installing step, the first sealing unit 150 constituted by the retaining member 151 and the sealing rings 153 securely retained by the retaining member 151 is installed on the first axial end 130a of the sleeve shaft 130 as shown in FIG. 5. The construction of the first sealing unit 150 has been described in the above as will be seen in FIG. 1.

In the third installing step, the fixed member 180 is installed on the first axial end 151a of the retaining member 151 of the first sealing unit 150, and the base member 190 is installed on the first axial end 140a of the center shaft 140. The constructions of the fixed member 180 and the base member 190 have been described in the above as will be seen in FIG. 1. The shaft sealing apparatus 100 is then assembled as shown in FIG. 1.

As will be seen from the foregoing description, the fact that the outer cylindrical surface of the driving shaft is smaller in surface roughness Ra than 0.1 μ m and larger in Vickers hardness Hv than 650 leads to the fact that the first embodiment of the shaft sealing apparatus according to the present invention makes it possible (1) to be excellent in characteristic to seal the gaps between the driving shaft and other parts around the driving shaft within a tolerance (less than 1×10^{-9} Pa m^3/s). In addition, the fact that the sealing lip of the sealing ring is made of a synthetic resin constituted by an ultra high molecular weight compound leads to the fact that the first embodiment of the shaft sealing apparatus according to the present invention makes it possible (2) to check the flow of gas. Further, the fact that each of the sealing units is installed in the shaft sealing apparatus leads to the fact that the first embodiment of the shaft sealing apparatus according to the present invention makes it possible (3) to be simple in construction, (4) to be reduced in size, (5) to be reduced in production cost, and (6) to be assembled with facility.

While the shaft sealing apparatus 100 has been described in the above as comprising a sleeve shaft 130 received in the shaft housing 120, and a center shaft 140 received in the sleeve shaft 130 as shown in FIG. 1, the sleeve shaft 130 and the center shaft 140 may be replaced by a driving shaft received in the shaft housing 120 according to the present invention.

The second embodiment directed to a driving shaft received in the shaft